

In 1957 I joined a group investigating ferrite core memory problems at University of Toronto, Physics under the direction of Prof Robert W McKay. Along about 1960 he had read that RCA in Lansdale Pennsylvania had samples of some experimental Light Emitting Diodes for sale. He asked me to send them a note enquiring on the price.

At the same time others in the Physics lab were working on experimental LASERS. Eric Rawson had a Helium-Neon Laser running while John Berry was working on a Ruby Laser. And Bill Gravelle had an apparatus used in zone refining of semiconductor materials. All of these leading edge in those days.



For all you techies out there, in 1869 Dimitri Mendeleev, a Russian scientist who had trained in Germany & France proposed a table of the known elements to include some slots for those yet to be discovered. At the time many scientists thought that to be unlikely. Within a few years both Gallium (1875) & Germanium (1885) were discovered to fill two of those missing slots.

All LEDs are constructed from elements in Columns 3 & 5 of Dimitri Mendeleev's Periodic Table. These can be brought together to form semiconductor materials of differing properties.

The common red LED basic material is Gallium Arsenide (GaAs). Other elements such as Aluminum (Al) & Indium (In) from Column 3 & Nitrogen (N), Phosphorus (P) & Antimony (Sb) from Column 5 are added as minute impurities in order to get the required characteristics for both electron donor (n) & acceptor (p) materials. Gallium Arsenide is also used as the active element in many microwave transistors. Gallium Nitride (GaN) is used in blue LEDs.

Perhaps by now you have thought, 'AHA!' Silicon is in Column 4 & it is a semiconductor & you are correct. Both Germanium & Silicon can be doped with minute quantities of impurities to form semiconductors. Near the bottom of column 4 you will also find Lead (Pb), the end product of the decomposition of nuclear materials.

All of these devices form a commanding part of our world today. They are in your car, your house & if you had one your airplane too. Without them, we would be back in the 1930s.

The cost for a single LED from RCA in 1960 was \$60.00. After inflation is taken into account that would be about \$500.00 today. Our research budget didn't have that much fat in it. Since we had no application for the LED in our project it was not purchased.

In 1965 I joined the sales group at Hewlett-Packard Canada. HP had set up an R&D group in California to investigate new technologies such as LEDs. HP Labs began building LEDs for sale

& by 1970 I had a few samples. They were a military grade device & sold for about \$10.00 each. I took some of these to places like Garrett & Litton Systems where both engineers & scientists alike were very impressed.

HP had sourced the LED materials, gallium arsenide, gallium phosphide & so on from Monsanto. Later HP built their own facility in San Jose, California to process these materials. They are dangerous if not handled properly but OK in the finished product. Growing the crystals is energy intensive. The reactors growing the crystals were fired by natural gas.

William Hewlett, one of HP's founders was always looking for new ways to get things done. With the new miniature 7-segment numerical LED displays in mind he challenged the development folks at HP to come up with a pocket sized engineering calculator. It was thought engineers & scientists might buy 10,000 of these each year. This first year resulted in 100,000 sales of the HP35 scientific pocket calculator. It was called the HP35 since it had 35 keys. My slide rule was now obsolete, DISRUPTIVE TECHNOLOGY in action.



For a while in the 70s I got to drive an HP80, the Financial Calculator. With the five financial variables at my fingertips, my interest & mortgage tables became obsolete. Yet another example of DISRUPTIVE TECHNOLOGY. Now the CA had a portable tool at hand.

Later Hewlett was travelling to various sales divisions. One morning as the group left the hotel for a meeting Hewlett saw a land survey party at work. On his return, work on the survey was still in progress. The story goes that Hewlett, being a hotshot designer in his own right while at dinner outlined on a table napkin his take on an optical distance measuring system. It would use one of the Infrared Emitting Diodes (IRED) then in development at HP Labs. The result was the HP 3800 family of distance measuring equipment, able to measure a mile or more with accuracy of better than an inch. The surveyors chain was no longer needed. Still another example of DISRUPTIVE TECHNOLOGY.



**Tech Alert!** Distance measurement by the HP 3800 Distance Meter depends on the accurate knowledge of the speed of light in the atmosphere. The HP3800 Series Distance Meter projects an Amplitude Modulated (AM) Infrared (IR) beam thru its optical system to a distant reflector system. Part of the same optics form a telescope to visually sight the target. Inside a dichroic mirror prevents the IR source from entering the sighting system.

Distance is calculated from the difference in phase of the projected wave to the returned wave. This is done at four or five increasingly short wavelengths & with some digital averaging to get the accuracy required. Corrections are made to take into account atmospheric pressure & curvature of the earth.

The instrument levelling system projects a light beam onto a pool of mercury (Hg). A quadrant of PIN Diodes detects the result & tells the operator which way to adjust the Tribach, a common piece of leveling hardware used by Civil Engineers & Land Surveyors. All microprocessor driven (not the Tribach).



By 1980 at HP we were selling commercial plastic encapsulated LEDs to large users at 7 or 8 cents each in quantities of a million. Besides the original red LEDs we could now offer yellow & green. The green was still not good but passable. There was quite a bit of variation from batch to batch.

The first blue LED I saw was at a trade show around 1990. It was not very bright & had to be shielded from the ambient illumination.

LEDs became a commodity, I'm not sure what the pricing is like now. The Opto Electronics Division (OED) of HP was sold off sometime after the splitting of Agilent Technologies from HP.

I still have my HP67 Engineering Calculator.....and my Pickett & Eckel slide rule.



John L Stewart P.Eng (Retired....finally)

When all else fails, read the manual.

Tektronix, 1960